Egyptian Journal of Chest Diseases and Tuberculosis (2016) 65, 71–79

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Egyptian Journal of Chest Diseases and Tuberculosis

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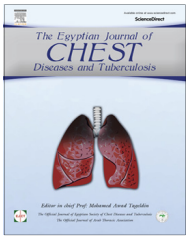

ORIGINAL ARTICLE

Poor man medical pneumoplasty: Bronchoscopic lung volume reduction with hot saline versus dissolved doxycycline as a neoteric remedy of pulmonary emphysema

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Received 9 June 2015; accepted 4 August 2015
Available online 24 August 2015

KEYWORDS

Lung volume reduction;
Hyperinflation;
Doxycycline;
CT chest;
Hot saline

Abstract *Background:* Endoscopic lung volume reduction maneuver using simple inexpensive reagents to remodel and shrivel damaged regions of the lung has been accomplished in managing human with pulmonary emphysema as a surrogate for surgical interference.

Objectives: Evaluation of the safety and efficacy of hot saline versus dissolved doxycycline (vibramycin) for lung volume reduction of emphysematous lung in both adult and pediatric age groups.

Patients and methods: Prospective clinical study was conducted on 21 patients with pulmonary emphysema. They were submitted to fiberoptic bronchoscopy (FOB), chest computed tomography (CT) and comprehensive respirometry. They were divided into two groups: group I underwent FOB instillation of hot saline with 50 °C in two consecutive sessions and group II underwent FOB instillation with dissolved doxycycline in normal saline also in two consecutive sessions, and each procedure then repeated after one week.

Results: The total success rate of the procedure in group I was 72.72% and in group II 70% however the total success rate in the studied cases was 71.43%. The procedure success in adult age group in group I represented 77.7% on the other hand in group II it reached 75% and the total therapeutic success rate was 76.74% while in the pediatric age group it accomplished an equal percentage (50%) in both groups.

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Peer review under responsibility of the Egyptian Society of Chest Diseases and Tuberculosis.

http://dx.doi.org/10.1016/j.ejcdt.2015.08.005

Conclusion: Bronchoscopic lung volume reduction by hot saline and dissolved doxycycline comes into sight to be a safe and feasible profile with an acceptable outcome that presents an attractive substitute to COPD patients who are physiologically friable.

Introduction

Chronic obstructive pulmonary disease (COPD) is the most common variety of primary pulmonary disablement [1] and an important cause of mortality when become advanced. As COPD becomes an end-stage disease, palliative surgical procedures, such as bullectomy for giant bullae, lung volume reduction surgery (LVRS) and lung transplantation, are the only impending treatments left over [2].

Studies conducted by Berger and Fishman have declared that lung volume reduction surgery (LVRS) improves dyspnea, increases exercise capacity, improves lung function, enhances health-related quality-of-life events and reduces mortality in selected patients with advanced emphysema [3,4]. Although beneficial to many emphysema patients, LVRS is associated with an operative mortality rate of 4–7%, a morbidity rate of 30–50%, and an average hospital stay of 10–14 days [5,6]. The development of less invasive and less morbid advances to lung volume reduction would represent a substantial progress in the treatment of emphysema [7]. Several bronchoscopic procedures designed to reduce lung volume in patients with emphysema are beneath research. These include one-way valves, [8–12] or bronchial occlusive devices to deflate emphysematous portions of the lung [13] and bronchial fenestration with bypass stents [14] to improve expiratory flow. Although some progress has been made using endobronchial valves, published pilot studies [11] have revealed contradictory alteration in pulmonary function. It is suggested that the wide-ranging collateral ventilation present in emphysematous lungs appears to limit the efficacy of endobronchial valves [15].

Biological agents aim to diminish lung volume via barricading the most emphysematous areas. The rapidly polymerizing sealant is designed to work at the alveolar level rather than in the airways. Their mechanism of action involves resorption atelectasis rather than airway occlusion, subsequent airspace inflammation, and then remodeling. This remodeling will lead to scarring-induced contraction of lung parenchyma and functional lung volume reduction can be expected within 6–8 weeks [16]. The sealant causes blockage of interalveolar as well as bronchiolar-alveolar collateral channels and contradicts the effects of collateral ventilation. This approach aims to achieve benefits by actual reductions in dead space that is physiologically similar to surgery [17].

Lung volume reduction aims to correct loss of elastic recoil by reducing the volume of the most damaged lung segments and allowing the remaining less damaged tissues to reformat. By eliminating parts of the emphysematous lung with the longest expiratory time constants and removing dead space, dynamic air trapping is reduced and exercise capacity can be increased. The working length of respiratory muscles is also normalized by restoring the normal dimensions of both the chest wall and the diaphragm [18].

Biological lung volume reduction appears to be secure and a dosage-dependent response has been identified. In order to achieve 20–30% of the lung volume that is removed in surgery, up to 12 subsegments may need to be sealed in future efficacy researches [17]. Unlike endobronchial valves, this therapy is not easily reversible and long-term follow up data are critical. There are also concerns that atelectasis may diminish with time because of biodegradation of the hydrogel [19]. An interesting parallel development has been the bronchoscopic injection of autologous blood and fibrinogen into bulla to simulate volume reduction [16].

In vapor steam LVR controlled bouts of steam, when delivered to a segmental airway, can produce an inflammatory response that results in lung volume reduction. The advantage of this technique is that no prosthesis needs to be inserted. A non-reusable 2 mm vapor catheter is inserted via flexible bronchoscopy to the identified airways. On the vapor catheter, there is a distal occlusion balloon that isolates the lung segment. A precise amount of steam generated by an electronically controlled pressure vessel is then delivered to these isolated airways. In a safety and feasibility trial, 11 patients with heterogeneous emphysema were treated unilaterally with a dose of 5 calories per gram of lung tissue [20]. So the aim of this study was to evaluate the safety and efficacy of hot saline versus dissolved doxycycline (vibramycin) for lung volume reduction of the emphysematous lung.

Aim of work

The aim of the work was the evaluation of the safety and efficacy of hot saline versus dissolved doxycycline (vibramycin) for lung volume reduction of the emphysematous lung in both adult and pediatric age groups.

Patients and methods

This prospective clinical study included 21 patients (17 chronic obstructive pulmonary disease patients (COPD) >18 years; 15 male and 2 females admitted in chest department, Mansoura University Hospital and 4 children; males <18 years (15-16-17-15) with alpha one antitrypsin deficiency admitted at Mansoura University Children Hospital (previously diagnosed by establishment of low serum levels with determination of the genotype and on regular follow up at outpatient clinic) during the period from June 2014 to May 2015. This study was conducted on patients to correlate the following standards:

Inclusion criteria

1. Emphysematous type of COPD.
2. Age 15–65 years.

3. Dyspnea >grade 2 by Modified research Council scale on routine daily activities despite maximal medical therapy.
4. Heterogeneous disease on CT chest.
5. Alpha one antitrypsin deficiency provided by serum level of enzyme with genotype detection.

Exclusion criteria

1. FEV1 <20% of predicted value.
2. Hypercapnea with $PaCO_2$ >55 mmHg.
3. Diffusion capacity DLCO <25% of predicted value.
4. Evidence of active pulmonary infection.
5. Patient cannot or will not comply with follow-up investigations.
6. Contraindications to fiberoptic bronchoscope.

They were divided according to the method used for lung volume reduction into two groups:

Group I

Physical pneumoplasty included 11 patients (9 of them >18 years and 2 of them <18 years) who underwent medical pneumoplasty (MP) with hot saline. Patients underwent 2 sessions in two successive days (10 cm hot saline with 50 °C) for each segment and only one lung can be injected at one session and the other lung can be injected in the second day.

The degree of hot saline 50 °C was selected to be equivalent to the degree of ablative thermal therapy utilized in direct tissue destruction of tumor cells as the normal degree of lung tissue is around 37 °C, equivalent to normal body temperature [21].

Group II

Chemical pneumoplasty included 10 patients (8 of them >18 years and 2 of them <18 years) who underwent medical pneumoplasty (MP) with doxycycline (vibramycin) dissolved with saline. Patients underwent 2 sessions in two successive days with (2 capsules; 200 mg; dissolved in 10 cm of doxycycline) for each segment and only one lung can be injected at one session and the other lung can be injected in the second day. Selecting doxycycline dose represents the minimal dose that can induce mucosal injury [22].

Both groups carried out two successive sittings with one week apart; the patient is exposed to the first sessions (either hot saline or dissolved doxycycline) in two consecutive days then exposed to the second session after one week with the same procedure.

Procedure

Patients were managed in the operating room under conscious sedation using short-acting IV agents (remifentanil or propofol). Electrocardiogram, blood pressure, pulse and arterial oxygen saturation levels were monitored throughout the procedure. The patients were locally anesthetized with lidocaine oral spray 5%. Arterial blood gas level determinations were obtained from a radial artery before and after the procedure. Following the patient preparation, a flexible bronchoscope (Pentax FB 19 TV; Tokyo, Japan) was introduced through the mouth; oral approach. The upper pulmonary lobes in one lung were reselected for lung volume reduction LVR treatment followed by lower lung lobes. The bronchus leading to the target segment was identified, and the bronchoscope was then advanced into wedge position in order to prevent the back return flow of LVR reagents. Wedging was tested by applying suction and observing elevation of the negative suction monitor degree. With the bronchoscope in a wedge position, the LVR procedure was performed as follows. (1) For the first group a total of 10 cm hot saline 0.9% with 50 °C previously deposited in boiled water till it reached the desired Celsius degree measured by Celsius thermometer; for each segment which was intended to deactivate the surfactant and promote the detachment of epithelial cells, was instilled through the working channel of the instrument (the amount prescribed and used was 100 ml for the right lung and 90–100 for the left lung according the number of segments). (2) For the second group, a total of (2 capsules of doxycycline (vibramycine); 200 mg; dissolved in 10 cm for each segment and only one lung can be injected at one session and the other lung can be injected in the second day. The injectable reagent was left in place and waiting for 2–5 min was conducted to evaluate the retrieval if being bloody due to pulmonary capillarities. The injectable substance was expected to promote inflammation and microatelectasis, facilitating remodeling of the hyperinflated lung through scar tissue formation. The bronchoscope was then positioned till the next treatment occasion, and the sequence of delivery of LVR reagents was repeated the next day for the other lung. The whole maneuver was conducted again after one week. As a precaution, patients were monitored overnight in the hospital. The primary safety endpoints of this method were the incidence of adverse effects detected. Complications encountered were haemoptysis, noncardiogenic pulmonary edema, segmental pneumonitis, pneumonia, fever, pneumothorax and commitment for mechanical ventilation. By patient interviews, physical examinations, ECGs, radiologic imaging, pulmonary function test were conducted at zero – 3 months of maneuver for procedure evaluation. Comprehensive respirometry was performed by Smart PFT Lab, Medical Equipment Europe GmbH, Germany, 2011 in Mansoura University Chest Department Respirometry Unit measuring FEV1, FVC, TLC, PEFR, FET and DLCO. Spirometric evaluation was performed in three different sessions and the best results were obtained on account of excluding inter-individual variability both at zero measurement and final 3 month assessment.

Lung volumetery by CT chest

As a radiographic technique, CT chest offers the potential for volume measurements of whole lung or specific regions or sections of lung. CT method utilizes the Volume Viewer (VV) software that has a large number of possibilities, and the user can quite freely choose how to use the program. In the end, the volume is calculated as the sum of all voxels left in the picture. This means that the user has to remove all unwanted structures from the picture to get the true volume of the object. The Volume Viewer software can be used in different ways. CT chest was performed in supine position, images were acquired with a multislice Light Speed virtual CT (VCT) 64 scanner (General

Electric, GEMS, Milwaukee, USA) with the following technical parameters: 1.25 mm collimation, 0.6-mm overlap, 0.5-s rotation time, 120 mA and 120 kVp.

Thresholding is one of many available options. By setting lower and upper thresholds, the user selects tissue within the wanted density interval. Other possibilities are to keep one specific object and eliminate all structures that are not connected to it, in 3D, or to remove unwanted structures by letting an erasing area grow. The erasing area is defined by the user who puts the cursor on a voxel, with the mouse button pressed. Voxels that are attached to that voxel will be selected. After this, voxels connected to these will be selected and so on until the user releases the button. At this moment all selected voxels will be deleted. Two operations dilate and erosions are available. In this case the meaning is add (dilate) or "peel" (erosion) from one up to 20 layers of voxels from the surface, and holes inside, of the current 3D object. The structuring element is in 3D and gets bigger when more layers are wanted to get added or peeled. It is also possible to invert the picture, to let all the erased voxels be shown instead of the previously selected [23].

Selection criteria

Patients were selected in random sample according to the time of medical consultation the former for group I and the latter for group II, and approval of admission to the hospital with signing on medical patient consent was given.

Procedure evaluation

The primary endpoint was death of the patients to restrain this procedure and the secondary endpoints were considered as a scale of summation of clinical, functional and radiological parameters; above certain score >7 *(that guarantees fulfillment of 70%; at least 4 pulmonary functions parameters were obtained)* the procedure was considered successful and below this score failure was the outcome. This scale performed for patients at zero – 3 months visits; was estimated after the second sitting.

Assessment scale parameter	Scoring value
Clinical criteria	
1. Improvement in MRC dyspnea scale	=1
2. Frequency of exacerbations <2 per week	=1
3. Hospital admissions <2 per month	=1
Functional criteria	
1. FEV1 improvement >12%	=1
2. TLC decrement If >20%	=1
3. DLCO improvement 20%	=1
4. Arterial blood gases improvement (persistent reduction of the level of hypoxemia from severe to moderate or from moderate to mild on room air)	=1
5. Forced expiratory time <6 s	=1
6. Peak expiratory flow rate improvement (PEFR measured by the average of three trials detect even minimal degree of increase)	=1
Radiological criteria	
Reduction of total lung volume >10% by CT chest (according to Coxson et al. [24])	=1

Score of the procedure:- total score = 10

- Successful procedure: if the patients score more than 7 points (that guarantees fulfillment of 70%; at least 4 pulmonary functions parameters were obtained).
- Failed procedure: if the patients score less than 7 points.

NB: 6 min walk test was not considered as most patients expressed osteoarthritis and or osteomalacia or patient rebuttal.

Statistical analysis

Data were analyzed using SPSS (Statistical Package for Social Sciences) version 21. Qualitative data were presented as number and percentage. Quantitative data were presented for normality by Kolmogrov–Smirnov test. Normally distributed data were presented as mean and standard deviation. Comparison between groups was done using Chi-square test. A Student *t*-test was used to compare between two groups. P value < 0.05 was considered significant.

Results

Table 1, shows that no documented statistical significance was detected between hot saline and dissolved doxycycline in lung volume reduction regarding secondary endpoints of assessment scale parameters. In the same way, the percentage of response of the patients for each monitoring parameter was approximated between the two methods; nevertheless, most of the parameters prevailed in hot saline group than doxycycline group, apart from the frequency of hospital admission and duration of forced expiratory time that dominated in group II. The total success rate of the procedure in group I was 72.72% and in group II 70% however the total success rate in the studied cases was 71.43%.

As shown in Table 2 the procedure success in adult age group in group I represented 77.7% on the other hand in group II it reached 75% and the total therapeutic success rate was 76.74% in while in the pediatric age group it accomplished an equal percentage (50%) in both groups.

As shown in Table 3 out of the 21 cases 7 cases developed complications (33.3%) that were detected in group I in the form of one case developing pneumonia and another case developing fever that resolved with nonspecific antimicrobial and antipyretic for 3 days without any remains however, in group II there was one case developing pneumonia one case developing fever and another case developing noncardiogenic pulmonary edema that necessitates mechanical ventilation for 4 days and a fourth case presenting with unilateral infiltrate without fever elevated C reactive protein or leucocytosis denoting segmental iatrogenic pneumonitis that managed by steroid for 5 days. No cases of mortality were recorded either during or post-procedure within 3 months.

All complications were encountered after the second sitting apart from haemoptysis and fever that were identified after the two sittings.

Discussion

Every now and then, medical and surgical efforts are continuously brought to bear for patients with pulmonary emphysema

Table 1 Demographic data and assessment scale parameters in studied cases.

	Group I (hot saline) $N = 11$	Group II (dissolved doxycycline) $N = 10$	Total	P value
Age group and sex				
Adult group	=8 Male + one female	=7 Male + one female	21 (100%)	
Children group	=2 Males	=2 Males		
Improvement in MRC dyspnea scale	11 (100%)	10 (100%)	21 (100%)	0.432
Frequency of exacerbations <2/week	9 (81.81%)	7 (70%)	16 (76.1%)	0.310
Hospital admissions <2/month	8 (72.72%)	8 (80%)	16 (76.1%)	0.521
FEV1 improvement >12%	9 (81.81%)	8 (80%)	17 (80.9%)	0.241
TLC decrement >20%	8 (72.72%)	7 (70%)	15 (71.4%)	0.231
DLCO improvement 20%	8 (72.72%)	7 (70%)	15 (71.4%)	0.231
Pulse oximeter improvement	9 (81.81%)	7 (70%)	16 (76.1%)	0.310
FET <6 s	8 (72.72%)	8 (80%)	16 (76.1%)	0.521
PEFR improvement	9 (81.81%)	7 (70%)	16 (76.1%)	0.310
Reduction of lung volume >10% by CT chest	9 (81.81%)	7 (70%)	16 (76.1%)	0.310
Cases fulfilled score >7 points	8 (72.72%)	7 (70%)	15 (71.4%)	0.231
Total	72.72%	70%	71.43%	0.435

FEV1 = forced expiratory volume in first second, TLC = total lung capacity, DLCO = level of diffusion of carbon monoxide, FET = forced expiratory time, PEFR = peak expiratory flow rate.

Table 2 Categorization of medical pneumoplasty success according to age group.

	Group I (hot saline) $N = 11$	Group II (dissolved doxycycline) $N = 10$	Total	P value
Adult age group ($n = 17$)	9	8	17	0.241
Successful procedure	7 (77.7%)	6 (75%)	13(76.74%)	0.356
Children age group ($n = 4$)	2	2	4	0.541
Successful procedure	1 (50%)	1 (50%)	2 (50%)	0.541

Table 3 Complications of medical pneumoplasty in studied cases.

	Group I hot saline $N = 11$	GROUP II dissolved doxycycline $N = 10$	Total
Non cardiogenic pulmonary edema	0	1	1
Iatrogenic segmental pneumonitis	0	1	1
Pneumonia	0	0	0
Haemoptysis	1	1	2
Fever	1	1	2
Necessity for mechanical ventilation	0	1	1
Pneumothorax	0	0	0
Bronchiolitis obliterans	0	0	0
Total	2	5	7

in order to minimize the respiratory suffer of them. The model of non-resectional lung volume reduction has emerged not long time ago. Many devices and strategies were innovated to achieve endoscopic lung volume reduction without the call for open surgery. These include iatrogenic segmental atelectasis using endobronchial sealants, occluding and inflammatory agents, or valves and creation of extra-anatomic tracts within the major airway to facilitate expiratory phase of airflow.

Endoscopic iatrogenic lung volume reduction LVR is the first-method biopharmaceutical that diminishes hyperinflation by initiating a localized induced inflammatory reaction, which collapses nonfunctional emphysematous lung. This reaction may be associated with leukocytosis, fever, malaise, shortness of breath, nausea, and pleuritic chest pain that develop in the majority of treated patients. These systemic manifestations of LVR therapy generally resolve within 24–48 h with supportive medical care including antipyretics, intravenous fluids and antimicrobials. Criner, Pinto-Plata, Strange, et al. [25] showed that LVR reagents instilled in eight segments can safely reduce lung volumes and improve pulmonary function with an acceptable side-effect profile, through the bronchoscopic coadministration of two liquid reagents that flow into the alveolar compartment and polymerize. The resulting hydrogel collapses and remodels the targeted lung region over 4–6 weeks. The hydrogel's physical properties and its site and mode of action overcome the effects of collateral ventilation, which limit the therapeutic effectiveness of endobronchial one-way valves designed to promote lung volume reduction through regional atelectasis [15,26]. There were no deaths during the course of their study. LVR produced changes in lung anatomy through biologic remodeling that were associated with improvements in lung physiology.

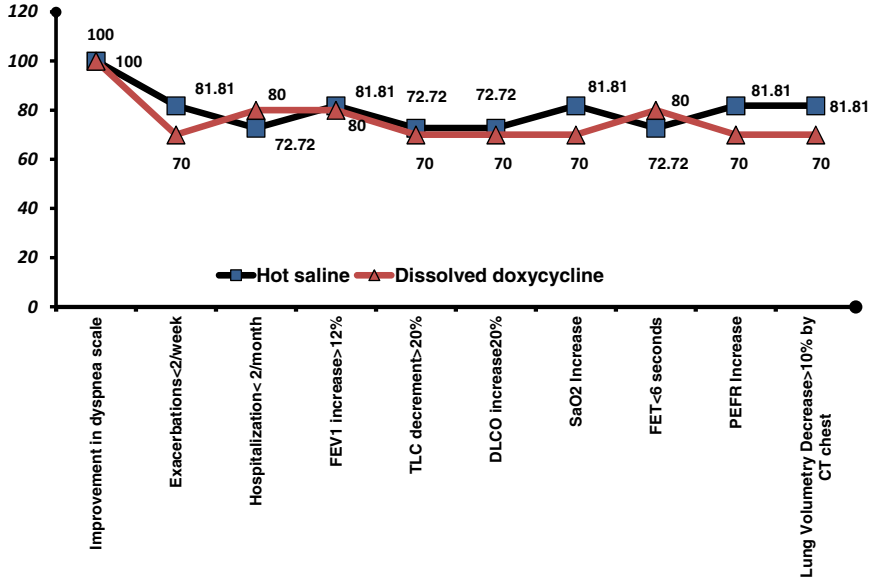

Figure 1 Diagram illustrates the percentages of scale parameters of assessment of LVR procedure success. FEV1 = forced expiratory volume in first second, TLC = total lung capacity, DLCO = level of diffusion of carbon monoxide, FET = forced expiratory time, PEFR = peak expiratory flow rate.

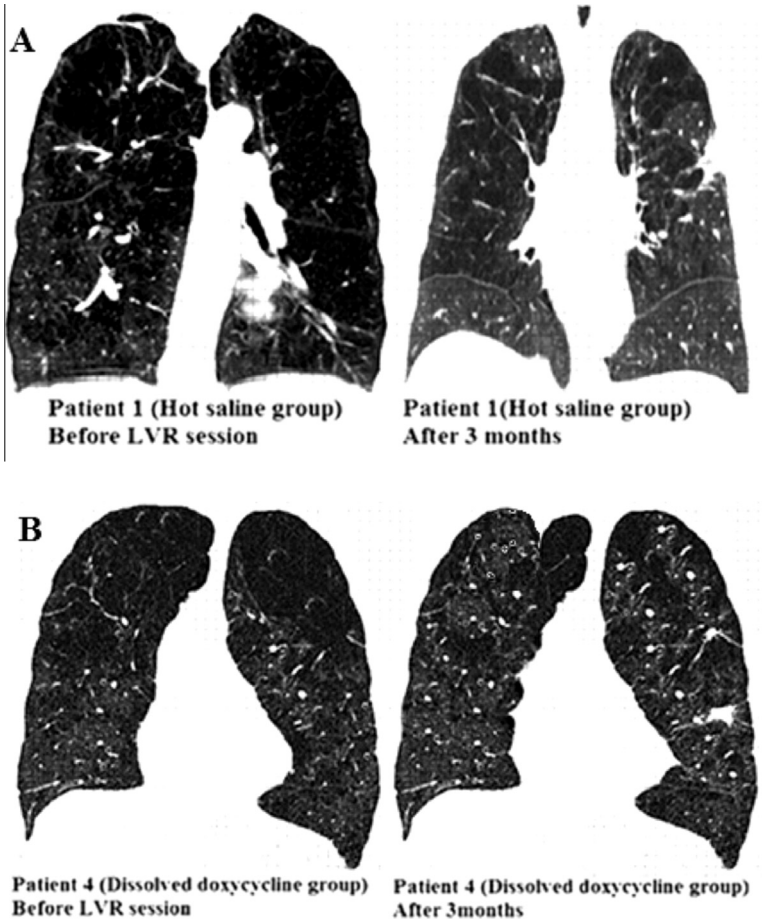

Figure 2 CT chest reformatting of (A) patient No. 1 performed LVR with hot saline showed reduced lung volume elevated diaphragmatic copula and rounded atelectasis, (B) patient No. 4 performed LVR with dissolved doxycycline showed reduced lung volume atelectatic areas, tracked areas.

In our study, hot saline can induce thermal lung injury to medium sized and alveolar lining membranes that induce inflammatory reactions, in turn, enhance alveolar and bronchiolar scarring with partial microatelectasis that modifies the segmental infrastructure declining the air trap and hence modifies the dynamic compression of hyperinflated lung. Staged thermal pneumoplasty by hot saline can thereafter graduate the hazard on temporary gas exchange impairment. On the other hand using sclerosant agent like doxycycline also carries the same idea of physical thermal pneumoplasty but through augmenting a chemically powerful irritant effect on alveolar and medium sized bronchioles with partial collapse to remodel the terminal airways and so improve the patient compliance.

In our research clinical background depends on summation of three clinical parameters that give surety about the actual improvement of disease state in our patients and guard against subjective variations. As for the analysis of the St George Respiratory Questionnaire [25] results, comparisons of data were not possible before 3 months, because some of the assessments within the questionnaire cannot be fully answered until then. In Criner study, 2009 [25] show the baseline values suggested a generalized impairment of patients' quality of life; the worst result obtained was in the activity score. Statistically significant improvements in all 4 domains measured were demonstrated at 90 days. Overall, 85% of the group that reported an improvement of dyspnea at 30 days after the procedure with the Medical Research Council dyspnea grade measurement demonstrated an improvement at 30 and 90 days ($P = 0.006$ and 0.003, respectively), thus indicating a significant reduction in the symptoms.

In our work respirometric parameters showed that FEV1, TLC, FET and DLCO were higher in hot saline group than doxycycline one, on the other hand PEFR and pulse oximetry were higher in doxycycline group and the total outcomes exceeds 70% that can be relied upon as parameter of success of the procedure (FEV1 = 80.9%, TLC = 71.4%, DLCO = 71.4%, Pulse oximeter = 76.1% PEFR = 76.1% and FET = 76.1%). By means of using certain cut off level as FEV1 > 12% and TLC > 20%, DLCO > 20% ameliorate the subjective chance of decision of functional improvement.

In accordance with Yim et al. [9] there were significant improvements in the mean value of FEV1 (percentage of predicted) and forced vital capacity (percentage of predicted) at each follow-up time point. The mean value of FEV1 was improved by 15% at 30 days and by 26% at 90 days, and this improvement was significant at 90 days ($P = 0.009$). The mean value of forced vital capacity also increased and became statistically significant at 90 days. Although there was a trend of improvement in the mean DLCO value by 15% and 13% at 30 and 90 days, respectively, after the procedure, these changes were not statistically significant. Likewise, lung volumes demonstrated a reduction of the residual volume and the total lung capacity, but the results did not reach statistical significance.

Compared with surgical and alternative endobronchial methods for achieving lung volume reduction, BioLVR demonstrated an acceptable overall safety profile in patients with severe emphysema. Serious pulmonary and cardiovascular complications within 30 days of treatment, defined as respiratory failure, re-intubation post-procedure, clinically significant hemoptysis, pneumonia, pulmonary embolus, cardiac ischemia, or arrhythmias, have been observed in up to 58% of patients treated with LVRS, 8–10% of patients treated with endobronchial valves, and 27% of patients treated with airway bypass [27–30]. In the Criner, Pinto-Plata, Strange, et al., 2009 study [25] 4 of 50 patients (8%) treated with BioLVR experienced such events. Although preliminary, these data suggest that BioLVR has a safety profile that is better than LVRS, and similar to other endobronchial lung volume reduction methods.

Criner, Pinto-Plata, Strange, et al. [25,26] after Bio-LVR, High resolution computed tomographic HRCT imaging showed scarring and atelectasis at treatment sites confirming the ability to endobronchially direct therapy to specific anatomic locations. BioLVR responses, which correspond radiologically to sites of increased linear density, occurred only at preselected target sites. Treatment was not associated with mediastinal, pleural, or parenchymal pathology beyond the anticipated remodeling reactions. Radiographic responses were observed more consistently, and were larger in size after high dose compared with low dose therapy of hydrogel, suggesting a relationship between the degree of anatomic remodeling and magnitude of post-treatment physiological and functional improvement. In a study by Yim et al. [9] three-dimensional CT scans provide a very accurate estimate of lung volume, and with thin CT thorax slices (collimation of 5 mm), good follow-up images can provide an estimation of the degree of emphysema in different segments of the lungs. Follow-up thorax CT at both at 30 and 90 days is essential, because there are cases of reexpansion and delayed collapse. In our study we depended on single objective measurement with the intention to rule out any subjective variability and avoid unintended bias by disqualifying inter-observer and intra-observer variability. Lung volumetry was detected by CT chest (computed tomography of chest) before the procedure and after 3 months of the bronchoscopic injection. Our patients showed only 81.81% in group I and 70% in group II atelectasis and volume retraction with fine scarring more than 10% of the primary lung volume or 300 ml according to Coxson et al. [24] regarding both adult and pediatric age groups as shown in Fig. 2.

Yim et al. [9] experienced that in their study that a total of 17 patients with 23 targeted lobes had complete CT evaluation at each follow-up for the degree of induced collapse. The degree of collapse of the respective lobes seen in the CT scans was categorized arbitrarily into 4 grades: grade 0 (0% collapse), grade 1 (> 25% collapse), grade 2 (25–75% collapse), and grade 3 (> 75% collapse). It is interesting to note that only 10 (43%) of the 23 lobes showed some degree of collapse during the entire follow-up period. Six of these 10 lobes remained unchanged throughout the follow-up period; whereas 2 lobes showed mild re-expansion and the remaining 2 showed no collapse at all in the first month but had a delayed collapse at the third month.

Our patients showed that no documented statistical significance was detected between hot saline and dissolved doxycycline in lung volume reduction regarding secondary endpoints of assessment scale parameters. In the same way, the percentage of response of the patients for each monitoring parameter was approximate between the two methods; nevertheless, most of the parameters prevailed in the hot saline group than doxycycline group, apart from the frequency of hospital admission and duration of forced expiratory time that dominated in group II. The total success rate of the procedure

in group I was 72.72% and in group II 70% however the total success rate in the studied cases was 71.43% as shown in Fig. 1.

According to Criner, Pinto-Plata, Strange, et al. [25] four medical complications were defined as serious occurred over 69 treatment sessions. Procedure-related COPD exacerbations were observed in 11 of 50 patients. All required hospitalization and were clinically significant, but resolved with conventional medical treatment and without long-term sequels.

In ours, exacerbations >2 week were documented in 18.18% in group I and 30% in group II and hospital admission was observed in 23.9% of all studied cases. Among the 27 patients completing follow-up of Criner study out to 6 months in the low dose group, the projected annual incidence of exacerbations between 1 and 6 months was 0.08 exacerbations per patient per year. Among the 17 patients in the high dose group completing follow-up over the same period, the projected annual incidence of exacerbations was 0.28 exacerbations per patient per year.

Out of our 21 cases 7 cases developed complications (33.3%) that were in group I in the form of one case developing pneumonia and one case developing fever that resolved with nonspecific antimicrobial and antipyretic for 3 days without any remains however, in group II there were one case that developed pneumonia one case that developed fever and another case that developed noncardiogenic pulmonary edema that necessitates mechanical ventilation for 4 days and a fourth case presented unilateral infiltrate without fever elevated C reactive protein or leucocytosis denoting segmental iatrogenic pneumonitis that was managed by steroid for 5 days with total improvement. No cases of mortality was recorded either during or post-procedure within 6 months.

In the current research, as shown in Table 2 the procedural success in the adult age group in group I represented 77.7% on the other hand in group II it reached 75% while in the pediatric age group it accomplished an equal percentage (50%) in both groups. Up to our knowledge no literature stated the efficacy of bronchoscopic lung volume reduction in the pediatric age group. Having therapeutic efficacy of 50% of conducted cases; despite this very small number of cases; it encourages our motivation to carry out more and more research in age below 18 years. Scarcity of cases of hyperinflated lung in children hinders this motive that necessitates long term studies to be carried out.

Conclusion

Once in a while medical professionalism urges pulmonologists to lend an accommodating hand to relieve the bearing of breathlessness of emphysematous patients. Bronchoscopic lung volume reduction by hot saline and dissolved doxycycloine come into sight to be a safe, feasible profile with an acceptable outcome that presents an attractive substitute to COPD patients who are physiologically delicate. Also it can help to wean patients off ventilators and may serve as overpass to surgery or lung transplant. In contrast, minimal clinically important differences in objective endpoints such as spirometry and radiological volumetry have been utilized as predictive findings adjuvant to clinical stability. Refinement of patient selection to identify optimal candidates for each individual endoscopic modality is likely to improve outcomes in future. Our study documented that medical pneumoplasty has a total therapeutic success rate of the procedure in the studied cases as 71.43%; (76.74% in adult while in the pediatric age group it accomplished 50%). It is also wished that the ongoing, larger randomized controlled trials will separate the therapeutic effect of these procedures.

Conflict of interest

No conflict of interest in this study.

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